Tentative Interim Amendment

NFPA 13

Standard for the Installation of Sprinkler Systems

2016 Edition

Reference: 2.3.1, 3.11.9, A.3.11.9, 9.3.5.12, A.9.3.5.12, A.9.3.5.12.1 and E.7
TIA 16-2
(SC 15-8-15 / TIA Log #1180)

Note: Text of the TIA was issued and incorporated into the document prior to printing, therefore no separate publication is necessary.

1. Revise the reference in 2.3.1 to read as follows:

2.3.1 ACI Publications.
American Concrete Institute, P.O. Box 9094, Farmington Hills, MI 48333.
ACI 318-14, *Building Code Requirements for Structural Concrete and Commentary*, 2014.
ACI 355.2, *Qualification of Post-Installed Mechanical Anchors in Concrete and Commentary*, 2007.

2. Add a new definition on Prying Factor and corresponding annex to read as follows:

3.11.9* Prying Factor. A factor based on fitting geometry and brace angle from vertical that results in an increase in tension load due to the effects of prying between the upper seismic brace attachment fitting and the structure.

A. 3.11.9 Prying factors in NFPA 13 are utilized to determine the design loads for attachments to concrete. Prying is a particular concern for anchorage to concrete because the anchor may fail in a brittle fashion.

3. Revise section 9.3.5.12 as follows:

9.3.5.12* Fasteners.
9.3.5.12.1 The designated angle category for the fastener(s) used in the sway brace installation shall be determined in accordance with Figure 9.3.5.12.1.

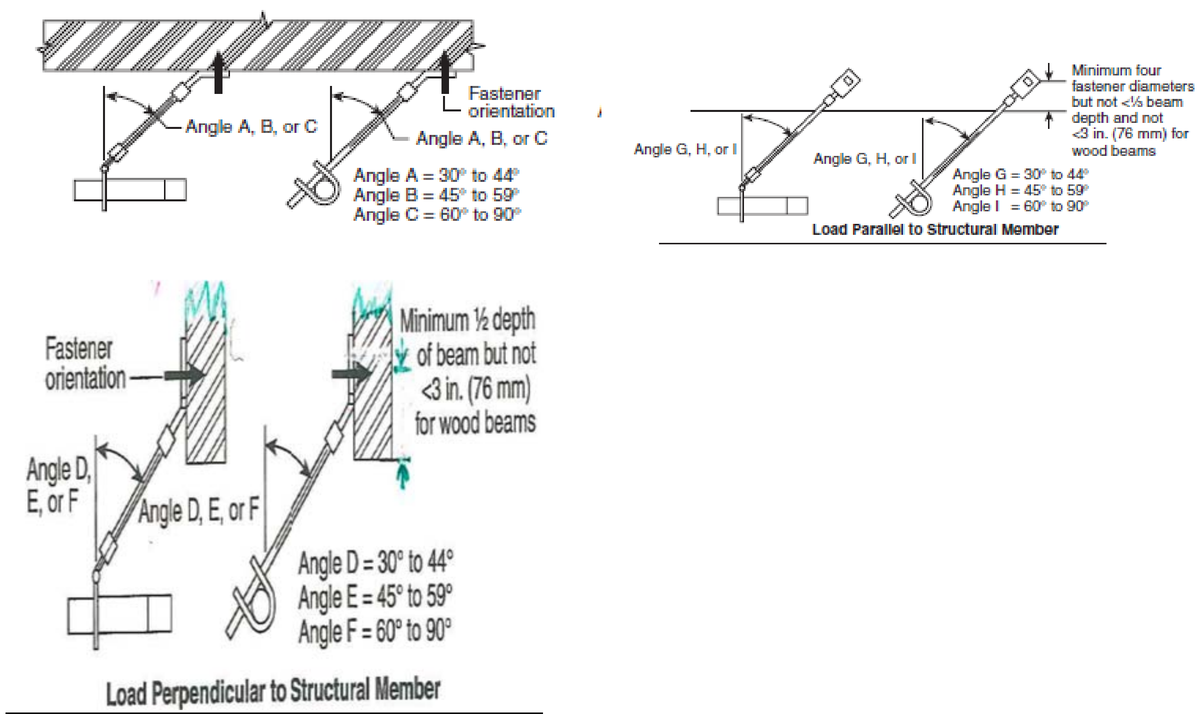


Figure 9.3.5.12.1 Designation of Angle Category Based on Angle of Sway Brace and Fastener Orientation.

9.3.5.12.~~1~~2* For individual fasteners, unless alternate allowable loads are determined and certified by a registered professional engineer, the loads determined in 9.3.5.9 shall not exceed the allowable loads provided in Tables 9.3.5.12.2(a) through 9.3.5.12.2(i)**.**

Table 9.3.5.12.2 (a) Maximum Load for Wedge Anchors in 3000 psi (207 bar) Lightweight Cracked Concrete on Metal Deck.

Wedge Anchors in 3000 psi Lightweight Cracked Concrete on Metal Deck (lbs.)										
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr < 2.0	*Pr* < 1.1	*Pr* < 0.7	*Pr* < 1.2	*Pr* < 1.1	*Pr* < 1.1	*Pr* < 1.4	*Pr* < 0.9	*Pr* < 0.8
3/8	2	117	184	246	-	-	-	-	-	-
1/2	2 3/8	164	257	344	-	-	-	-	-	-
5/8	3 1/8	214	326	424	-	-	-	-	-	-
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr 2.1 - 3.5	*Pr* 1.2 - 1.8	*Pr* 0.8 - 1.0	*Pr* 1.3 - 1.7	*Pr* 1.2 - 1.8	*Pr* 1.2 - 2.0	*Pr* 1.5 - 1.9	*Pr* 1.0 - 1.3	*Pr* 0.9 - 1.1
3/8	2	69	127	196	-	-	-	-	-	-
1/2	2 3/8	97	178	274	-	-	-	-	-	-
5/8	3 1/8	133	232	346	-	-	-	-	-	-
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr 3.6 - 5.0	*Pr* 1.9 - 2.5	*Pr* 1.1 - 1.3	*Pr* 1.8 - 2.2	*Pr* 1.9 - 2.5	*Pr* 2.1 - 2.9	*Pr* 2.0 - 2.4	*Pr* 1.4 - 1.7	*Pr* 1.2 - 1.4
3/8	2	48	97	163	-	-	-	-	-	-
1/2	2 3/8	67	136	228	-	-	-	-	-	-
5/8	3 1/8	93	179	292	-	-	-	-	-	-
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr 5.1 - 6.5	*Pr* 2.6 - 3.2	*Pr* 1.4 - 1.6	*Pr* 2.3 - 2.7	*Pr* 2.6 - 3.2	*Pr* 3.0 - 3.8	*Pr* 2.5 - 2.9	*Pr* 1.8 - 2.1	*Pr* 1.5 - 1.7
3/8	2	36	75	139	-	-	-	-	-	-
1/2	2 3/8	51	106	196	-	-	-	-	-	-
5/8	3 1/8	71	146	252	-	-	-	-	-	-

* Pr = Prying Factor Range. (Refer to Annex for additional information.)
1 lb = 0.45 kg

Table 9.3.5.12.2 (b) Maximum Load for Wedge Anchors in 3000 psi (207 bar) Lightweight Cracked Concrete

Wedge Anchors in 3000 psi Lightweight Cracked Concrete (lbs.)										
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr < 2.0	*Pr* < 1.1	*Pr* < 0.7	*Pr* < 1.2	*Pr* < 1.1	*Pr* < 1.1	*Pr* < 1.4	*Pr* < 0.9	*Pr* < 0.8
3/8	2	102	144	175	101	144	184	87	128	152
1/2	2 3/8	140	196	238	137	196	251	118	174	207
5/8	3 1/4	222	308	372	215	308	397	220	272	323
3/4	4 1/8	327	469	580	336	469	586	289	426	504
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr 2.1 - 3.5	*Pr* 1.2 - 1.8	*Pr* 0.8 - 1.0	*Pr* 1.3 - 1.7	*Pr* 1.2 - 1.8	*Pr* 1.2 - 2.0	*Pr* 1.5 - 1.9	*Pr* 1.0 - 1.3	*Pr* 0.9 - 1.1
3/8	2	69	109	150	87	109	121	76	110	133
1/2	2 3/8	94	149	205	119	149	166	104	150	181
5/8	3 1/4	151	237	322	187	237	265	201	236	285
3/4	4 1/8	217	351	492	286	351	380	252	362	436
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr 3.6 - 5.0	*Pr* 1.9 - 2.5	*Pr* 1.1 - 1.3	*Pr* 1.8 - 2.2	*Pr* 1.9 - 2.5	*Pr* 2.1 - 2.9	*Pr* 2.0 - 2.4	*Pr* 1.4 - 1.7	*Pr* 1.2 - 1.4
3/8	2	52	88	132	76	88	90	68	97	118
1/2	2 3/8	71	121	180	104	121	124	93	132	161
5/8	3 1/4	114	192	284	165	192	198	185	208	254
3/4	4 1/8	162	280	427	249	280	281	223	315	385
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr 5.1 - 6.5	*Pr* 2.6 - 3.2	*Pr* 1.4 - 1.6	*Pr* 2.3 - 2.7	*Pr* 2.6 - 3.2	*Pr* 3.0 - 3.8	*Pr* 2.5 - 2.9	*Pr* 1.8 - 2.1	*Pr* 1.5 - 1.7
3/8	2	41	74	117	68	74	70	61	86	106
1/2	2 3/8	56	101	160	93	101	97	84	118	145
5/8	3 1/4	91	161	253	148	161	157	172	186	230
3/4	4 1/8	124	233	378	221	233	214	200	279	344

* Pr = Prying Factor Range. (Refer to Annex for additional information.)
1 lb = 0.45 kg

Table 9.3.5.12.2 (c) Maximum Load for Wedge Anchors in 3000 psi (207 bar) Normal Weight Cracked Concrete

Wedge Anchors in 3000 psi Normal Weight Cracked Concrete (lbs.)										
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr < 2.0	*Pr* < 1.1	*Pr* < 0.7	*Pr* < 1.2	*Pr* < 1.1	*Pr* < 1.1	*Pr* < 1.4	*Pr* < 0.9	*Pr* < 0.8
3/8	2	171	240	292	169	240	307	145	214	254
1/2	3 5/8	412	567	682	394	567	735	340	498	592
5/8	3 7/8	480	668	809	468	668	859	479	591	703
3/4	4 1/8	545	780	965	559	780	976	482	709	839
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr 2.1 - 3.5	*Pr* 1.2 - 1.8	*Pr* 0.8 - 1.0	*Pr* 1.3 - 1.7	*Pr* 1.2 - 1.8	*Pr* 1.2 - 2.0	*Pr* 1.5 - 1.9	*Pr* 1.0 - 1.3	*Pr* 0.9 - 1.1
3/8	2	116	183	252	146	183	203	128	184	223
1/2	3 5/8	282	438	592	344	438	493	302	434	523
5/8	3 7/8	327	512	699	406	512	571	438	512	618
3/4	4 1/8	363	584	819	477	584	634	420	604	727
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr 3.6 - 5.0	*Pr* 1.9 - 2.5	*Pr* 1.1 - 1.3	*Pr* 1.8 - 2.2	*Pr* 1.9 - 2.5	*Pr* 2.1 - 2.9	*Pr* 2.0 - 2.4	*Pr* 1.4 - 1.7	*Pr* 1.2 - 1.4
3/8	2	87	148	221	128	148	152	114	162	198
1/2	3 5/8	214	357	523	305	357	371	271	384	469
5/8	3 7/8	247	415	615	359	415	428	404	452	551
3/4	4 1/8	271	467	712	416	467	468	371	526	641
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr 5.1 - 6.5	*Pr* 2.6 - 3.2	*Pr* 1.4 - 1.6	*Pr* 2.3 - 2.7	*Pr* 2.6 - 3.2	*Pr* 3.0 - 3.8	*Pr* 2.5 - 2.9	*Pr* 1.8 - 2.1	*Pr* 1.5 - 1.7
3/8	2	69	124	197	115	124	118	103	145	178
1/2	3 5/8	173	301	469	274	301	296	247	345	425
5/8	3 7/8	197	349	549	321	349	337	374	404	498
3/4	4 1/8	208	389	629	369	389	357	333	465	573

* Pr = Prying Factor Range. (Refer to Annex for additional information.)
1 lb = 0.45 kg

Table 9.3.5.12.2 (d) Maximum Load for Wedge Anchors in 4000 psi (276 bar) Normal Weight Cracked Concrete

Wedge Anchors in 4000 psi Normal Weight Cracked Concrete (lbs.)										
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr < 2.0	*Pr* < 1.1	*Pr* < 0.7	*Pr* < 1.2	*Pr* < 1.1	*Pr* < 1.1	*Pr* < 1.4	*Pr* < 0.9	*Pr* < 0.8
3/8	2	200	282	344	199	282	359	171	251	299
1/2	3 5/8	430	607	742	430	607	770	370	544	645
5/8	3 7/8	532	729	872	505	729	950	511	636	758
3/4	4 1/8	630	903	1117	647	903	1129	558	821	971
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr 2.1 - 3.5	*Pr* 1.2 - 1.8	*Pr* 0.8 - 1.0	*Pr* 1.3 - 1.7	*Pr* 1.2 - 1.8	*Pr* 1.2 - 2.0	*Pr* 1.5 - 1.9	*Pr* 1.0 - 1.3	*Pr* 0.9 - 1.1
3/8	2	135	214	295	171	214	236	150	216	261
1/2	3 5/8	289	460	636	370	460	506	325	467	563
5/8	3 7/8	367	566	760	442	566	642	470	557	672
3/4	4 1/8	419	676	948	552	676	733	486	699	841
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr 3.6 - 5.0	*Pr* 1.9 - 2.5	*Pr* 1.1 - 1.3	*Pr* 1.8 - 2.2	*Pr* 1.9 - 2.5	*Pr* 2.1 - 2.9	*Pr* 2.0 - 2.4	*Pr* 1.4 - 1.7	*Pr* 1.2 - 1.4
3/8	2	101	172	258	150	172	176	134	190	232
1/2	3 5/8	218	370	556	325	370	377	290	410	500
5/8	3 7/8	280	463	674	393	463	484	435	494	603
3/4	4 1/8	313	540	824	481	540	541	430	608	741
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr 5.1 - 6.5	*Pr* 2.6 - 3.2	*Pr* 1.4 - 1.6	*Pr* 2.3 - 2.7	*Pr* 2.6 - 3.2	*Pr* 3.0 - 3.8	*Pr* 2.5 - 2.9	*Pr* 1.8 - 2.1	*Pr* 1.5 - 1.7
3/8	2	79	144	230	134	144	137	121	169	209
1/2	3 5/8	170	310	494	289	310	292	261	365	449
5/8	3 7/8	226	391	605	354	391	389	406	445	547
3/4	4 1/8	241	449	728	427	449	413	386	538	663

* Pr = Prying Factor Range. (Refer to Annex for additional information.)
1 lb = 0.45 kg

Table 9.3.5.12.2(e) Maximum Load for Wedge Anchors in 6000 psi (414 bar) Normal Weight Cracked Concrete

Wedge Anchors in 6000 psi Normal Weight Cracked Concrete (lbs.)										
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr < 2.0	*Pr* < 1.1	*Pr* < 0.7	*Pr* < 1.2	*Pr* < 1.1	*Pr* < 1.1	*Pr* < 1.4	*Pr* < 0.9	*Pr* < 0.8
3/8	2 1/4	254	354	428	199	354	585	213	313	372
1/2	3 5/8	527	744	910	418	744	1227	454	667	791
5/8	3 7/8	652	893	1069	504	893	1481	626	780	928
3/4	4 1/8	772	1106	1369	622	1106	1819	684	1005	1190
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr 2.1 - 3.5	*Pr* 1.2 - 1.8	*Pr* 0.8 - 1.0	*Pr* 1.3 - 1.7	*Pr* 1.2 - 1.8	*Pr* 1.2 - 2.0	*Pr* 1.5 - 1.9	*Pr* 1.0 - 1.3	*Pr* 0.9 - 1.1
3/8	2 1/4	172	271	370	215	271	302	188	271	327
1/2	3 5/8	355	564	780	453	564	621	399	573	690
5/8	3 7/8	450	694	932	542	694	786	576	682	823
3/4	4 1/8	514	828	1162	676	828	898	595	856	1030
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr 3.6 - 5.0	*Pr* 1.9 - 2.5	*Pr* 1.1 - 1.3	*Pr* 1.8 - 2.2	*Pr* 1.9 - 2.5	*Pr* 2.1 - 2.9	*Pr* 2.0 - 2.4	*Pr* 1.4 - 1.7	*Pr* 1.2 - 1.4
3/8	2 1/4	130	219	325	189	219	226	169	239	292
1/2	3 5/8	267	454	682	398	454	462	355	502	613
5/8	3 7/8	343	567	826	481	567	593	534	606	739
3/4	4 1/8	384	662	1009	590	662	663	527	745	909
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr 5.1 - 6.5	*Pr* 2.6 - 3.2	*Pr* 1.4 - 1.6	*Pr* 2.3 - 2.7	*Pr* 2.6 - 3.2	*Pr* 3.0 - 3.8	*Pr* 2.5 - 2.9	*Pr* 1.8 - 2.1	*Pr* 1.5 - 1.7
3/8	2 1/4	103	184	290	170	184	178	153	214	263
1/2	3 5/8	209	380	606	355	380	358	320	447	551
5/8	3 7/8	277	480	741	433	480	476	497	545	671
3/4	4 1/8	295	551	892	523	551	506	473	660	813

* Pr = Prying Factor Range. (Refer to Annex for additional information.)
1 lb = 0.45 kg

Table 9.3.5.12.2(f) Maximum Load for Undercut Anchors in 3000 psi (207 bar) Normal Weight Cracked Concrete

Undercut Anchors in 3000 psi Normal Weight Cracked Concrete (lbs.)										
Diameter (in.)	Embedment (in.)	A	B	C	D	E	F	G	H	I
		Pr < 2.0	*Pr* < 1.1	*Pr* < 0.7	*Pr* < 1.2	*Pr* < 1.1	*Pr* < 1.1	*Pr* < 1.4	*Pr* < 0.9	*Pr* < 0.8
3/8	4 3/8	501	638	726	420	638	889	362	525	630
1/2	7	700	911	1051	608	911	1245	525	761	912
5/8	9 1/2	1106	1535	1855	1074	1535	1975	1098	1356	1612
3/4	12	1701	2404	2946	1707	2404	3041	1472	2161	2561
Diameter (in.)	Embedment (in.)	A	B	C	D	E	F	G	H	I
		Pr 2.1 - 3.5	*Pr* 1.2 - 1.8	*Pr* 0.8 - 1.0	*Pr* 1.3 - 1.7	*Pr* 1.2 - 1.8	*Pr* 1.2 - 2.0	*Pr* 1.5 - 1.9	*Pr* 1.0 - 1.3	*Pr* 0.9 - 1.1
3/8	4 3/8	368	526	658	381	526	643	333	477	578
1/2	7	505	738	942	547	738	882	479	685	829
5/8	9 1/2	754	1179	1604	933	1179	1318	1005	1177	1419
3/4	12	1143	1819	2520	1468	1819	1996	1291	1854	2233
Diameter (in.)	Embedment (in.)	A	B	C	D	E	F	G	H	I
		Pr 3.6 - 5.0	*Pr* 1.9 - 2.5	*Pr* 1.1 - 1.3	*Pr* 1.8 - 2.2	*Pr* 1.9 - 2.5	*Pr* 2.1 - 2.9	*Pr* 2.0 - 2.4	*Pr* 1.4 - 1.7	*Pr* 1.2 - 1.4
3/8	4 3/8	291	447	601	350	447	504	309	437	534
1/2	7	395	620	854	497	620	683	440	622	760
5/8	9 1/2	572	957	1413	825	957	989	927	1039	1268
3/4	12	860	1463	2202	1287	1463	1486	1149	1624	1980
Diameter (in.)	Embedment (in.)	A	B	C	D	E	F	G	H	I
		Pr 5.1 - 6.5	*Pr* 2.6 - 3.2	*Pr* 1.4 - 1.6	*Pr* 2.3 - 2.7	*Pr* 2.6 - 3.2	*Pr* 3.0 - 3.8	*Pr* 2.5 - 2.9	*Pr* 1.8 - 2.1	*Pr* 1.5 - 1.7
3/8	4 3/8	241	389	554	323	389	414	287	403	496
1/2	7	324	535	780	455	535	557	407	570	701
5/8	9 1/2	456	806	1263	739	806	781	859	931	1145
3/4	12	670	1223	1955	1146	1223	1147	1035	1444	1778

* Pr = Prying Factor Range. (Refer to Annex for additional information.)
1 lb = 0.45 kg

Table 9.3.5.12.2(g) Maximum Load for Connections to Steel Using Unfinished Steel Bolts

Connections to Steel (Values Assume Bolt Perpendicular to Mounting Surface)																	
Diameter of Unfinished Steel Bolt (in.)																	
¼									⅜								
A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I
400	500	600	300	500	650	325	458	565	900	1200	1400	800	1200	1550	735	1035	1278
Diameter of Unfinished Steel Bolt (in.)																	
½									⅝								
A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I
1600	2050	2550	1450	2050	2850	1300	1830	2260	2500	3300	3950	2250	3300	4400	2045	2880	3557

Table 9.3.5.12.2(h) Maximum Load for Through-Bolts in Sawn Lumber or Glue-Laminated Timbers

Through-Bolts in Sawn Lumber or Glue-Laminated Timbers (Load Perpendicular to Grain)

Bolt Diameter (in.): ½

Length of Bolt in Timber (in.)	A	B	C	D	E	F	G	H	I
1½	115	165	200	135	230	395	130	215	310
2½	140	200	240	160	280	480	165	275	410
3½	175	250	305	200	350	600	200	330	485
5½	—	—	—	—	—	—	—	—	—

Bolt Diameter (in.): ⅝

Length of Bolt in Timber (in.)	A	B	C	D	E	F	G	H	I
1½	135	190	235	155	270	460	155	255	380
2½	160	225	280	185	320	550	190	320	495
3½	200	285	345	230	400	685	235	405	635
5½	280	395	485	325	560	960	315	515	735

Bolt Diameter (in.): ¾

Length of Bolt in Timber (in.)	A	B	C	D	E	F	G	H	I
1½	155	220	270	180	310	530	170	300	450
2½	180	255	310	205	360	615	215	365	575
3½	220	310	380	255	440	755	260	455	730
5½	310	440	535	360	620	1065	360	610	925

Note: Wood fastener maximum capacity values are based on the 2001 National Design Specifications (NDS) for wood with a specific gravity of 0.35. Values for other types of wood can be obtained by multiplying the above values by the factors in Table 9.3.5.12.2(j).

Table 9.3.5.12.2(i) Maximum Load for Lag Screws and Lag Bolts in Wood

Lag Screws and Lag Bolts in Wood (Load Perpendicular to Grain — Holes Predrilled Using Good Practice)

Lag Bolt Diameter (in.): ⅜

Length of Bolt in Timber (in.)	A	B	C	D	E	F	G	H	I
3½	165	190	200	170	220	310	80	120	170
4½	180	200	200	175	235	350	80	120	170
5½	190	200	200	175	245	380	80	120	170
6½	195	205	200	175	250	400	80	120	170

Lag Bolt Diameter (in.): ½

Length of Bolt in Timber (in.)	A	B	C	D	E	F	G	H	I
3½	—	—	—	—	—	—	—	—	—
4½	300	355	380	315	400	550	145	230	325
5½	320	370	380	320	420	610	145	230	325
6½	340	375	380	325	435	650	145	230	325

Lag Bolt Diameter (in.): ⅝

Length of Bolt in Timber (in.)	A	B	C	D	E	F	G	H	I
3½	—	—	—	—	—	—	—	—	—
4½	—	—	—	—	—	—	—	—	—
5½	435	525	555	425	550	775	195	320	460
6½	465	540	555	430	570	840	195	320	460

Note: Wood fastener maximum capacity values are based on the 2001 National Design Specifications (NDS) for wood with a specific gravity of 0.35. Values for other types of wood can be obtained by multiplying the above values by the factors in Table 9.3.5.12.2(i).

Table 9.3.5.12.2(j) Factors for Wood Based on Specific Gravity

Specific Gravity of Wood	Multiplier
0.36 thru 0.49	1.17
0.50 thru 0.65	1.25
0.66 thru 0.73	1.50

9.3.5.12.3* The type of fasteners used to secure the bracing assembly to the structure shall be limited to those shown in Tables 9.3.5.12.2(a) through 9.3.5.12.2(i) or to listed devices.

A.9.3.5.12.3 Listed devices may have accompanying software that performs the calculations to determine the allowable load.

9.3.5.12.4* For connections to wood, through-bolts with washers on each end shall be used, unless the requirements of 9.3.5.12.5 are met.

9.3.5.12.5 Where it is not practical to install through-bolts due to the thickness of the wood member in excess of 12 in. (305 mm) or inaccessibility, lag screws shall be permitted and holes shall be pre-drilled 1⁄8 in. (3.2 mm) smaller than the maximum root diameter of the lag screw.

9.3.5.12.6 Holes for through-bolts and similar listed attachments shall be 1⁄16 in. (1.6 mm) greater than the diameter of the bolt.

9.3.5.12.7 The requirements of 9.3.5.12 shall not apply to other fastening methods, which shall be acceptable for use if certified by a registered professional engineer to support the loads determined in accordance with the criteria in 9.3.5.9.

9.3.5.12.7.1 Calculations shall be submitted where required by the authority having jurisdiction.

9.3.5.12.8 Concrete Anchors.
9.3.5.12.~~7~~8.1* Concrete anchors shall be prequalified for seismic applications in accordance with ACI 355.2, *Qualification of Post-Installed Mechanical Anchors in Concrete and Commentary*, and installed in accordance with the manufacturer's instructions.

A.9.3.5.12.8.1 Concrete anchors included in current Evaluation Service Reports conforming to the requirements of acceptance criteria AC193~~ or AC308~~ as issued by ICC Evaluation Service, Inc. should be considered to meet ACI 355.2, *Qualification of Post-Installed Mechanical Anchors in Concrete &Commentary*.

9.3.5.12.8.2
Unless the requirements of 9.3.5.12.8.3 are met, concrete anchors shall be selected from Table 9.3.5.12.2(a) through Table 9.3.5.12.2(f) based on concrete strength, anchor type, designated angle category A through I, prying factor (*Pr*) range, and allowable maximum load.

9.3.5.12.8.2.1 Sway brace manufacturers shall provide prying factors (*Pr)* based on geometry of the structure attachment fitting and the designated angle category A through I as shown in Figure 9.3.5.12.1.

9.3.5.12.8.2.2 Where the prying factor for the fitting is unknown, the largest prying factor range in Tables 9.3.5.12.2(a) through 9.3.5.12.2(f) for the concrete strength and designated angle category A through I shall be used.

9.3.5.12.8.3 In lieu of using the concrete anchor loads in Tables 9.3.5.12.2(a) through 9.3.5.12.2(f)**,** the allowable maximum load may be calculated.

(A) Allowable concrete anchor loads shall be permitted to be determined using approved software that considers the effects of prying for concrete anchors.

(B) Anchors shall be seismically prequalified per 9.3.5.12.8.1.

(C)Allowable maximum loads shall be based on the anchor capacities given in approved evaluation service reports, where the calculation of ASD allowable shear and tension values are determined in accordance with ACI 318, Chapter 17 and include the effects of prying, brace angle, and the over strength factor (**Ω**=2.0).

(D)* The shear and tension values determined in 9.3.5.12.8.3(C) using ACI 318, Chapter 17 shall be multiplied by 0.43.

A.9.3.5.12.8.3(D) The values from ACI 318, Chapter 17 are strength (LRFD) values that must be divided by 1.4 in order to convert them to ASD values. The factor of 0.43 was created to simplify the steps needed to account for the strength capacities and the ASD method of calculation. The 0.43 is a rounded value determined by 1.2 (allowable stress increase) divided by the quantity of 2.0 times 1.4 (i.e. 0.4286=1.2/(2.0*1.4)).

9.3.5.12.8.4 Concrete anchors other than those shown in Tables 9.3.5.12.2(a) through 9.3.5.12.2(f) shall be acceptable for use where designed in accordance with the requirements of the building code and certified by a registered professional engineer.

4. Revise A.9.3.5.12 to read as follows:

A.9.3.5.12
Current fasteners for anchoring to concrete are referred to as post-installed anchors. There are several types of post-installed anchors, including expansion anchors, chemical or adhesive anchors, and undercut anchors. The criteria in Tables 9.3.5.12.2(a) through 9.3.5.12.2(f) are based on the use of wedge expansion anchors and undercut anchors. Use of other anchors in concrete should be in accordance with the listing provisions of the anchor. Anchorage designs are usable under allowable stress design (ASD) methods.

Values in Tables 9.3.5.12.2(a) through 9.3.5.12.2(f) are based on ultimate strength design values obtained using the procedures in ACI 318-11, Appendix D, which are then adjusted for ASD. Wedge anchors are torque-controlled expansion anchors that are set by applying a torque to the anchor's nut, which causes the anchor to rise while the wedge stays in place. This causes the wedge to be pulled onto a coned section of the anchor and presses the wedge against the wall of the hole. Undercut anchors might or might not be torque-controlled. Typically, the main hole is drilled, a special second drill bit is inserted into the hole, and flare is drilled at the base of the main hole. Some anchors are self-drilling and do not require a second drill bit. The anchor is then inserted into the hole and, when torque is applied, the bottom of the anchor flares out into the flared hole, and a mechanical lock is obtained. Consideration should be given with respect to the position near the edge of a slab and the spacing of anchors. For full capacity in Tables 9.3.5.12.2(a) through 9.3.5.12.2(f)**,** the edge distance spacing between anchors and thickness of concrete should conform to the anchor manufacturer's recommendations.

Calculation of ASD Shear and Tension Values to be used in A.9.3.5.12.1 calculations should be performed in accordance with ACI 318, Chapter 17 formulas using the variables and recommendations obtained from the approved evaluation service reports (such as ICC-ES Reports) for a particular anchor, which should then be adjusted to ASD values. All post-installed concrete anchors must be prequalified in accordance with ACI 355.2 or other approved qualification procedures. This information is usually available from the anchor manufacturer.

The variables below are among those contained in the approved evaluation reports for use in ACI 318, Chapter 17 calculations. These variables do not include the allowable tension and shear capacities, but provide the information needed to calculate them. The strength design capacities must be calculated using the appropriate procedures in ACI 318 Chapter 17, and then converted to allowable stress design capacities.
D_a = Anchor diameter
h_{nom} = Nominal Embedment
h_{ef} = Effective Embedment
h_{min} = Min. Concrete Thickness

C_{ac} = Critical Edge Distance
N_{sa} = Steel Strength in Tension
l_e = Length of Anchor in Shear
$N_{p,cr}$ = Pull-Out Strength Cracked Concrete
K_{cp} = Coefficient for Pryout Strength
$V_{sa,eq}$ = Shear Strength Single Anchor Seismic Loads
$V_{st.deck,eq}$ = Shear Strength Single Anchor Seismic Loads installed through the soffit of the metal deck

5. Replace A.9.3.5.12.1 with the following (retain and renumber all figures):

A.9.3.5.12.~~1~~2 The values for the wedge anchor tables and the undercut anchor tables have been developed using the following formula:

$$\left(\frac{T}{Tallow}\right) + \left(\frac{V}{Vallow}\right) \leq 1.2$$

where:

T = applied service tension load including the effect of prying (F_{pw} x Pr)
F_{pw} = Horizontal Earthquake Load
Pr = prying factor based on fitting geometry and brace angle from vertical
T_{allow} = allowable service tension load
V = applied service shear load
V_{allow} = allowable service shear load

$T/\ T_{allow}$ shall not be greater than 1.0.
$V/\ V_{allow}$ shall not be greater than 1.0.

The allowable tension and shear loads come from the anchor manufacturer's published data. The design loads have been amplified by an over-strength factor of 2.0, and the allowable strength of the anchors has been increased by a factor of 1.2. The effect of prying on the tension applied to the anchor is considered when developing appropriate capacity values. The applied tension equation includes the prying effect which varies with the orientation of the fastener in relationship to the brace necessary at various brace angles. The letters A through D in the following equations are dimensions of the attachment geometry as indicated in Figures A.9.3.5.12.2(a) through A.9.3.5.12.2(c).
where:

Cr = critical angle at which prying flips to the toe or the heel of the structure attachment fitting.
Pr = Prying factor for service tension load effect of prying
$Tan\Theta$ = Tangent of Brace Angle from vertical
$Sin\Theta$ = Sine of Brace Angle from vertical
The greater Pr value calculated in Tension or Compression applies
The Pr value cannot be less than 1.000/$Tan\Theta$ for designated angle category A, B and C, 1.000 for designated angle category D, E and F or 0.000 for designated angle category G, H, and I.

For designated angle category A, B and C, the Applied Tension including the effect of prying (*Pr*) is as follows:

$$Cr = Tan^{-1}(\frac{C}{D})$$

For braces acting in **TENSION**:
If *Cr* >Brace angle from vertical

$$Pr = \left(\left(\frac{\mathrm{C} + \mathrm{A}}{Tan\Theta}\right) - \mathrm{D}\right)/\mathrm{A}$$

If *Cr* < Brace angle from vertical

$$Pr = (D - \left(\frac{C - B}{Tan\Theta}\right))/B$$

For braces acting in **COMPRESSION**:

If *Cr* > Brace angle from vertical

$$Pr = (\left(\frac{C - B}{Tan\Theta}\right) - D)/B$$

If *Cr* < Brace angle from vertical

$$Pr = (D - \left(\frac{C + A}{Tan\Theta}\right))/A$$

For designated angle category D, E and F, the Applied Tension including the effect of prying (*Pr*) is as follows:

$$Cr = Tan^{-1}(\frac{D}{C})$$

For braces acting in **TENSION**:

If *Cr* >Brace angle from vertical

$$Pr = \left(\left(\frac{\mathrm{D}}{Tan\Theta}\right) - (C - B)\right)/\mathrm{B}$$

If *Cr* < Brace angle from vertical

$$Pr = ((\mathrm{C} + \mathrm{A}) - \left(\frac{\mathrm{D}}{Tan\Theta}\right))/\mathrm{A}$$

For braces acting in **COMPRESSION**:

If *Cr* > Brace angle from vertical

$$Pr = \left(\left(\frac{\mathrm{D}}{Tan\Theta}\right) - (C + A)\right)/\mathrm{A}$$

If *Cr* < Brace angle from vertical

$$Pr = ((\mathrm{C} - B) - \left(\frac{\mathrm{D}}{Tan\Theta}\right))/\mathrm{B}$$

For designated angle category G, H and I the Applied Tension including the effect of prying (*Pr*) is as follows:

For braces acting in **TENSION**:

$$Pr = (\frac{D}{B})/Sin\theta$$

For braces acting in **COMPRESSION**:

$$Pr = (\frac{D}{A})/Sin\,\theta$$

The lightweight concrete anchor tables 9.3.5.12.2(a) and (b) were based on sand lightweight concrete which represents a conservative assumption for the strength of the material. For seismic applications cracked concrete was assumed.

6. Add a new Annex E.7 to read as follows:

E.7 Allowable Loads for Concrete Anchors. The following sections provide step-by-step examples of the procedures for determining the allowable loads for concrete anchors as they are found in Tables 9.3.5.12.2(a) through 9.3.5.12.2(f). Tables 9.3.5.12.2(a) through (f) were developed using the prying factors found in Table E.7(a) and the representative strength design seismic shear and tension values for concrete anchors found in Table E.7(b).

Table E.7(a) Prying Factors for Table 9.3.5.12.2(a) through Table 9.3.5.12.2(f) Concrete Anchors

Pr Range	**Fig. 9.3.5.12.1** Designated Angle Category								
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Lowest	2.0	1.1	0.7	1.2	1.1	1.1	1.4	0.9	0.8
Low	3.5	1.8	1.0	1.7	1.8	2.0	1.9	1.3	1.1
High	5.0	2.5	1.3	2.2	2.5	2.9	2.4	1.7	1.4
Highest	6.5	3.2	1.6	2.7	3.2	3.8	2.9	2.1	1.7

Table E.7(b)Representative Strength Design Seismic Shear and Tension Values Used for Concrete Anchors

Wedge Anchors in 3000 psi LW Sand Concrete on Metal Deck			
Anchor Dia. (in.)	Nominal Embedment (in.)	LRFD Tension (lbs.)	LRFD Shear (lbs.)
3/8	2	573	1172
1/2	2.375	804	1616
5/8	3.125	1102	1744

Wedge Anchors in 3000 psi LW Sand Concrete			
Anchor Dia. (in.)	Nominal Embedment (in.)	LRFD Tension (lbs.)	LRFD Shear (lbs.)
3/8	2	637	550
1/2	3.625	871	745
5/8	3.875	1403	1140
3/4	4.125	1908	1932

Wedge Anchors in 3000 psi NW Concrete			
Anchor Dia. (in.)	Nominal Embedment (in.)	LRFD Tension (lbs.)	LRFD Shear (lbs.)
3/8	2	1063	917
1/2	3.625	2639	2052
5/8	3.875	3004	2489
3/4	4.125	3179	3206

Wedge Anchors in 4000 psi NW Concrete			
Anchor Dia. (in.)	Nominal Embedment (in.)	LRFD Tension (lbs.)	LRFD Shear (lbs.)
3/8	2	1226	1088
1/2	3.625	2601	2369
5/8	3.875	3469	2586
3/4	4.125	3671	3717

Wedge Anchors in 6000 psi NW Concrete			
Anchor Dia. (in.)	Nominal Embedment (in.)	LRFD Tension (lbs.)	LRFD Shear (lbs.)
3/8	2.25	1592	1322
1/2	3.625	3186	2902
5/8	3.875	4249	3167
3/4	4.125	4497	4553

Undercut Anchors in 3000 psi NW Concrete			
Anchor Dia. (in.)	Nominal Embedment (in.)	LRFD Tension (lbs.)	LRFD Shear (lbs.)
3/8	5	4096	1867
1/2	7	5322	2800
5/8	9.5	6942	5675
3/4	12	10182	9460

E.7.1 Procedure for Selecting a Wedge Anchor Using Tables 9.3.5.12.2(a) through 9.3.5.12.2(f).

Step 1. Determine the ASD Horizontal Earthquake Load F_{pw}.

Step 1a. Calculate the weight of the water-filled pipe within the Zone of Influence of the brace.

Step 1b. Find the applicable Seismic Coefficient C_p in Table 9.3.5.9.3

Step 1c. Multiply the Zone of Influence weight by C_p to determine the ASD Horizontal Earthquake Load F_{pw}.

Step 2. Select a concrete anchor from Tables 9.3.5.12.2(a) through 9.3.5.12.2(f) with a maximum load capacity that is greater than the calculated horizontal earthquake load F_{pw} from Step 1.

Step 2a. Locate the table for the applicable concrete strength.

Step 2b. Find the column in the selected table for the applicable designated angle category (A thru I) and the appropriate prying factor *Pr* range.

Step 2c. Scan down the category column to find a concrete anchor diameter, embedment depth, and maximum load capacity that is greater than the calculated horizontal earthquake load F_{pw} from Step 1.

(ALTERNATIVE) Step 2. As an alternative to using the maximum load values in Tables 9.3.5.12.2(a) through 9.3.5.12.2(f), select an AC355.2 seismically pre-qualified concrete anchor with a load-carrying capacity that exceeds the calculated F_{pw}, with calculations, including the effects of prying, based on seismic shear and tension values taken from an ICC-ES Report and calculated in accordance with ACI 318, Chapter 17 and adjusted to ASD values by multiplying by 0.43 per 9.3.5.12.8.3(D).

EXAMPLE

Step 1. Zone of Influence F_{pw}.

Step 1a.

40 ft. of 2½" Sch. 10 pipe plus 15% Fitting Allowance

40 x 5.89 lbs/ft x 1.15 = 270.94 lbs

Step 1b. Seismic Coefficient *Cp* from Table 9.3.5.9.3

C_p = 0.35

Step 1c. F_{pw} = 0.35 x 270.94 = 94.8 lbs.

Step 2. Select a concrete anchor from Tables 9.3.5.12.2(a) through 9.3.5.12.2(f).

Step 2a. Using the table for 4000 psi Normal Weight Concrete.

Step 2b. Fastener Orientation "A" – assume the manufacturers prying factor is 3.0 for the fitting. Use the *Pr* range of 2.1 – 3.5.

Step 2c. Allowable F_{pw} on 3/8" dia. with 2" embedment = 135 lbs and is greater than the Calculated F_{pw} of 94.8 lbs.

E.7.2 Calculation Procedure for Maximum Load Capacity of Concrete Anchors. This example shows how the effects of prying and brace angle are calculated.

Step 1. Determine the Allowable Seismic Tension Value (T_{allow}) and the Allowable Seismic Shear Value (V_{allow}) for the anchor, based on data found in the in the anchor manufacturer's approved evaluation report. Note that, in this example, it is assumed the evaluation report provides the allowable tension and shear capacities. If this is not the case, then the strength design anchor capacities must be determined using the procedures in ACI 318, Chapter 17, which are then converted to ASD values by dividing by a factor of 1.4. As an alternative to calculating the Allowable Seismic Tension Value (T_{allow}) and the Allowable Seismic Shear Value (V_{allow}) for the anchor, the seismic tension and shear values that were used to calculate the Figure 9.3.5.12.1 for anchor allowable load tables may be used.

Step 1a. Find the ASD Seismic Tension capacity (T_{allow}) for the anchor according to the strength of concrete, diameter of the anchor, and embedment depth of the anchor. Divide the ASD tension value by 2.0 and then multiply by 1.2.

Step 1b. Find the ASD Seismic Shear capacity (V_{allow}) for the anchor according to the strength of concrete, diameter of the anchor, and embedment depth of the anchor. Divide the ASD shear value by 2.0 and then multiply by 1.2.

Step 2. Calculate the Applied Seismic Tension (*T*) and the Applied Seismic Shear (*V*) based on the Calculated Horizontal Earthquake Load F_{pw}.

Step 2a. Calculate the designated angle category Applied Tension Factor Including the Effects of Prying (*Pr*) using the following formulas:

Category "A", "B" and "C"

$$Pr = \left(\left(\frac{\mathrm{C} + \mathrm{A}}{Tan\theta}\right) - \mathrm{D}\right)/\mathrm{A}$$

Category "D", "E" and "F"

$$Pr = ((\mathrm{C} + \mathrm{A}) - \left(\frac{\mathrm{D}}{Tan\theta}\right))/\mathrm{A}$$

Category "G", "H" and "I"

$$Pr = (\frac{D}{B}) / \, Sin\theta$$

Step 2b. Calculate the ASD Applied Seismic Tension (*T*) on the anchor, including the effects of prying, and when applied at the applicable brace angle from vertical and the designated angle category (A thru I) using the following formula:

$$T = F_{pw} \text{ x } Pr$$

Step 2c. Calculate the ASD Applied Seismic Shear (*V*) on the anchor, when applied at the applicable brace angle from vertical and the designated angle category (A thru I) using the following formulas:

Category "A", "B" and "C"

$$V = F_{pw}$$

Category "D", "E" and "F"

$$V = Fpw/Tan\theta$$

Category "G", "H" and "I"

$$V = F_{pw}/Sin\theta$$

Step 3. Check the anchor for combined tension and shear loads using the formula:

$$\left(\frac{T}{Tallow}\right) + \left(\frac{V}{Vallow}\right) \leq 1.2$$

Confirm T/T_{allow} *&* $V/V_{allow} <= 1.0$

EXAMPLE
Sample Calculation, Maximum Load Capacity
of
Concrete Anchors as Shown in Tables 9.3.5.12.2(a) through 9.3.5.12.2(f)

In this example, a sample calculation is provided showing how the values in Tables 9.3.5.12.2(a) through 9.3.5.12.2(f) were calculated.

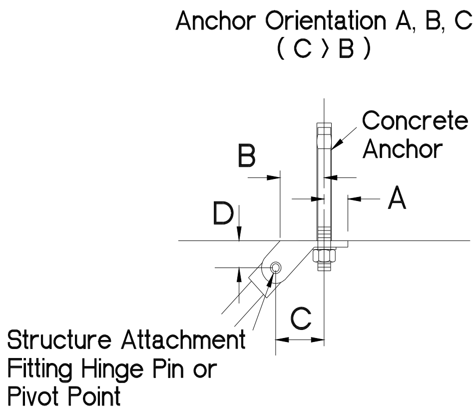
Step 1. Determine the Allowable Seismic Tension Value (T_{allow}) and the Allowable Seismic Shear Value (V_{allow}) for a concrete anchor in Figure 9.3.5.12.1.

Step 1a. The Table E.7(b) Strength Design Seismic Tension Value (T_{allow}) for a 1/2" Carbon Steel Anchor with 3 5/8" Embedment Depth in 4,000 psi Normal Weight Concrete is 2601 lbs. Therefore, the Allowable Stress Design Seismic Tension Value (T_{allow}) is 2601 / 1.4 / 2.0 x 1.2 = 1115 lbs.
Step 1b. The Table E.7(b) Strength Design Seismic Shear Value (V_{allow}) for a 1/2" Carbon Steel Anchor with 3 5/8" embedment is 2369 lbs. Therefore, the Allowable Stress Design Seismic Shear Value (V_{allow}) is 2369 / 1.4 / 2.0 x 1.2 = 1015 lbs.

Step 2. Using the Applied Seismic Tension Value (*T*) and the Applied Seismic Shear Value (*V*) based on an ASD Horizontal Earthquake Load (F_{pw}) of 170 lbs, a 30° brace angle from vertical and designated angle category "A".

Step 2a. Calculate the ASD Applied Seismic Tension Value (*T*) on the anchor, including the effects of prying, using the formula:

$$T = (Fpw\left(\left(\frac{C + A}{Tan\theta}\right) - D\right))/A$$



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where:
T = applied service tension load including the effect of prying
F_{pw} = Horizontal Earthquake Load (F_{pw} = 170)
Tan = Tangent of Brace Angle from vertical ($Tan\theta\,30°$ = 0.5774)
A = 0.7500
B = 1.5000
C = 2.6250
D = 1.0000

$T = F_{pw}$ x Pr

$$T = (Fpw\left(\left(\frac{2.625 + 0.75}{0.5774}\right) - 1.0\right))/0.75$$
$$T = (Fpw\ (5.8452 - 1.0))/0.75$$
$$T = (Fpw\ ((5.8452) - 1.0))/0.75$$
$$T = Fpw\ (\frac{4.8451}{0.75})$$
$$T = Fpw \text{ x } 6.46$$
$$T = 170 \text{ lbs x } 6.46 = 1098.2 \text{ lbs}$$

Step 2b. The ASD Applied Seismic Shear Value (*V*) on the anchor for anchor orientations "A", "B" & "C" is equal to the ASD Horizontal Earthquake Load (*Fpw*) = 170 lbs.

Step 3 Calculate the maximum Allowable Horizontal Earthquake Load *Fpw* using the formula:

$$\left(\frac{T}{Tallow}\right) + \left(\frac{V}{Vallow}\right) \leq 1.2$$

$$\left(\frac{1098.2}{1115}\right) + \left(\frac{170}{1015}\right) = .9849 + .1675 = 1.1524 \ (\leq \mathbf{1.2})$$

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(**Note: For further information on NFPA Codes and Standards, please see** www.nfpa.org/codelist)